**Saudi Electricity Company**
Centeral Region Branch

الشركة السعودية للكهرباء
فرع المنطقة الوسطى

# 132kV CT SIZING CALCULATION

| NO. | DATE | BY | DESCRIPTION | CHEK'D | APP'D | CERT'D |
|---|---|---|---|---|---|---|
| 0 | 1-Feb-11 | DAR | ISSUED FOR BASE DEISGN | Yahia | M.A. | |
| 1 | 7-Jan-12 | DAR | Modified as per SEC letter No.030343/0107/11, Dated 31 May 11 | Yahia | M.A. | |
| | | | | | | |

**REVISIONS**

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| DESIGNED | |
| BY:- | MV |
| DATE:- | Feb - '11 |
| CHECKED | |
| BY:- | AS |
| DATE:- | Feb - '11 |
| OPRG. DEPT | |
| BY | |
| DATE:- | Feb - '11 |
| ENG'G. DEPT. | |
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THIS DRAWING IS NOT TO BE USED FOR CONSTRUCTION OF FOR ORDERING MATERIALS UNTIL CERTIFIED AND DATED

| AS BUILT BY | | DATE | 26-02-2011 | | |
|---|---|---|---|---|---|
| DOCUMENT TITLE | INDEX | PLANT | DOCUMENT NO. | SHEET NO. | REV. |
| 132kV CT SIZING CALCULATION FOR 9027 SUBSTATIION | A | C257 | CE-180973 | 1 OF 50 | 1 |
| INDUSTRIAL AREA RIYADH SAUDI ARABIA | JOB ORDER NO. | | DWG.CON. SHT. CE-180791 | | |

| | Sr. No | CT No | Function | Relay Type | CT Primary ( Amp) | Adopted Tap ( Amp) | CT Secondary | CT Class | CT Knee Point Voltage | CT Knee Point Voltage At Adopted Tap | CT Magnetizing Current ( mAmp ) | CT Magnetizing Current At Selected Tap | CT Resistance (Ohms) | CT Resistance Selected Tap (Ohms) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 132kV Bay No=D12, =D17, =D24 ( SPARE CAPACITOR & SVC BAYS ) | 1 | T1 CORE-1 | MAIN-1 PROTN (FUTURE) | - | 3000-2500-2000-1600-1200-1000 | 1000 | 1 | X | 4200-3500-2800-2240-1680-1400 | 1400 | 8.33-10-12.5-15.6-20.8-25 | 25 | 6-5-3.2-2.4-2 | 2 |
| | 2 | T1 CORE-2 | MAIN-2 PROTN (FUTURE) | - | 3000-2500-2000-1600-1200-1000 | 1000 | 1 | X | 4200-3500-2800-2240-1680-1400 | 1400 | 8.33-10-12.5-15.6-20.8-25 | 25 | 6-5-3.2-2.4-2 | 2 |
| | 3 | T1 CORE-3 | SPARE | - | 3000-2500-2000-1600-1200-1000 | NA | 1 | X | 4200-3500-2800-2240-1680-1400 | NA | 8.33-10-12.5-15.6-20.8-25 | 25 | 6-5-3.2-2.4-2 | NA |
| | 4 | T2 CORE-1 | METERING | - | 3000-2500-2000-1600-1200-1000 | 1000 | 1 | X | 4200-3500-2800-2240-1680-1400 | 1400 | 8.33-10-12.5-15.6-20.8-25 | 25 | 6-5-3.2-2.4-2 | 2 |
| | 5 | T2 CORE-2 | 87B (DISC ZONE) | 7SJ64 | 4000 | 4000 | 1 | X | 800 | NA | 25 | NA | 6 | NA |
| | 6 | T2 CORE-3 | 87B (CHK ZONE) | 7SJ64 | 4000 | 4000 | 1 | X | 800 | NA | 25 | NA | 6 | NA |

| | Sr. No | CT No | Function | Relay Type | CT Primary ( Amp) | Adopted Tap ( Amp) | CT Secondary | CT Class | CT Knee Point Voltage | CT Knee Point Voltage At Adopted | CT Magnetizing Current ( mAmp ) | CT Magnetizing Current At Selected | CT Resistance (Ohms) | CT Resistance Selected Tap (Ohms) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 132kV Bay No=D01, =D02, =D03, =D07, =D08, =D11, =D13, =D15, =D19, =D16, =D18, =D20, =D22 ( SPARE UG & OHL FEEDERS ) | 1 | T1 CORE-1 | LOCAL CABLE PROTN (FUTURE) | - | 1600-1200-800-600 | 800 | 1 | X | 2800-2100-1400-1050 | 1400 | 12.5-16.7-25-33.3 | 25 | 4-3-2-1.5 | 2 |
| | 2 | T1 CORE-2 | MAIN-1 PROTN (FUTURE) | - | 1600-1200-800-600 | 800 | 1 | X | 2800-2100-1400-1050 | 1400 | 12.5-16.7-25-33.3 | 25 | 4-3-2-1.5 | 2 |
| | 3 | T1 CORE-3 | MAIN-2 PROTN (FUTURE) | - | 1600-1200-800-600 | 800 | 1 | X | 2800-2100-1400-1050 | 1400 | 12.5-16.7-25-33.3 | 25 | 4-3-2-1.5 | 2 |
| | 4 | T2 CORE-1 | METERING | - | 1600-1200-800-600 | 800 | 1 | X | 2800-2100-1400-1050 | 1400 | 12.5-16.7-25-33.3 | 25 | 4-3-2-1.5 | 2 |
| | 5 | T2 CORE-2 | 87B (DISC ZONE) | 7SJ64 | 4000 | 4000 | 1 | X | 800 | NA | 25 | NA | 6 | NA |
| | 6 | T2 CORE-3 | 87B (CHK ZONE) | 7SJ64 | 4000 | 4000 | 1 | X | 800 | NA | 25 | NA | 6 | NA |

| | Sr. No | CT No | Function | Relay Type | CT Primary ( Amp) | Adopted Tap ( Amp) | CT Secondary | CT Class | CT Knee Point Voltage | CT Knee Point Voltage At Adopted | CT Magnetizing Current ( mAmp ) | CT Magnetizing Current At Selected | CT Resistance (Ohms) | CT Resistance Selected Tap (Ohms) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 132kV Bay No=D04, =D09, =D10 ( 132/13.8kV GT Bays ) | 1 | T1 CORE-1 | SPARE | - | 300 | 300 | 1 | 5P20, 30VA | NA | NA | NA | NA | NA | NA |
| | 2 | T1 CORE-2 | MAIN-1 PROTN (BOX-1) | 7UT6 | 300 | 300 | 1 | X | 360 | 360 | 50 | 50 | 1 | 1 |
| | 3 | T1 CORE-3 | MAIN-2 PROTN (BOX-2) | RET670 | 300 | 300 | 1 | X | 360 | 360 | 50 | 50 | 1 | 1 |
| | 4 | T2 CORE-1 | 87B (DISC ZONE) | 7SJ64 | 4000 | 4000 | 1 | X | 800 | NA | 25 | NA | 6 | NA |
| | 5 | T2 CORE-2 | 87B (CHK ZONE) | 7SJ64 | 4000 | 4000 | 1 | X | 800 | NA | 25 | NA | 6 | NA |

| | Sr. No | CT No | Function | Relay Type | CT Primary ( Amp) | Adopted Tap ( Amp) | CT Secondary | CT Class | CT Knee Point Voltage | CT Knee Point Voltage At Adopted | CT Magnetizing Current ( mAmp ) | CT Magnetizing Current At Selected | CT Resistance (Ohms) | CT Resistance Selected Tap (Ohms) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 132kV Bay No=D21, =D26 ( 132kV Reactor Bays ) | 1 | T1 CORE-1 | FR + METERING +CBF1,2 | 7VK61 + P141 | 1200-600-400-200 | 200 | 1 | X | 2400-1200-800-400 | 400 | 8.33-16.7-25-50 | 50 | 6-3-2-1 | 1 |
| | 2 | T1 CORE-2 | 50/51N + 50BF | 7SJ64 | 1200-600-400-200 | 200 | 1 | X | 2400-1200-800-400 | 400 | 8.33-16.7-25-50 | 50 | 6-3-2-1 | 1 |
| | 3 | T1 CORE-3 | 87C | 7SJ64 | 1200-600-400-200 | 1200 | 1 | X | 2400-1200-800-400 | 2400 | 8.33-16.7-25-50 | 8.33 | 6-3-2-1 | 6 |
| | 4 | T2 CORE-1 | 87B (DISC ZONE) | 7SJ64 | 4000 | 4000 | 1 | X | 800 | NA | 25 | NA | 6 | NA |
| | 5 | T2 CORE-2 | 87B (CHK ZONE) | 7SJ64 | 4000 | 4000 | 1 | X | 800 | NA | 25 | NA | 6 | NA |
| Shunt Reactor Bushing CTs | 1 | LC1-1 | 87R | REC670 | 600-400-200 | 200 | 1 | X | NOT AVILABLE | 400 | NOT AVILABLE | 52 | NOT AVILABLE | 1 |
| | 2 | LC1-2 | 87C | 7SJ64 | 1200-600-400-200 | 1200 | 1 | X | | | | | | |
| | 3 | NC1-1 | 49 ( WIND TEMP ) | | | | | | | | | | | |
| | 4 | NC2-1 | 87R | 7SJ64 | 600-400-200 | 200 | 1 | X | | 400 | | 50 | | 1 |
| | 5 | NC2-2 | 51NR | 7SJ64 | 400 | 400 | 1 | 5P20, 15VA | | | | | | |

| | Sr. No | CT No | Function | Meter / Relay Type | CT Primary ( Amp) | Adopted Tap ( Amp) | CT Secondary | CT Class | CT Knee Point Voltage | CT Knee Point Voltage At Adopted | CT Magnetizing Current ( mAmp ) | CT Magnetizing Current At Selected | CT Resistance (Ohms) | CT Resistance Selected Tap (Ohms) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 132kV Bay No=D05, =D06, =D14 ( 132kV SIDE SGT BAYS ) | 1 | T1 CORE-1 | METERING | Alpha-A3 | 3000-1500 | 1500 | 1 | 0.2FS5, 30-15VA | NA | NA | NA | NA | NA | NA |
| | 2 | T1 CORE-2 | SGT 132kV SIDE 50/51NS + | 7SJ64 | 3000 | 3000 | 1 | X | 1000 | 1000 | 25 | 25 | 7 | 7 |
| | 3 | T1 CORE-3 | 87C2 | REC670+ RAEDK | 3000 | 3000 | 1 | X | 1000 | 1000 | 25 | 25 | 7 | 7 |
| | 4 | T1 CORE-4 | 87C1 | 7SJ64+ RAEDK | 3000 | 3000 | 1 | X | 1000 | 1000 | 25 | 25 | 7 | 7 |
| | 5 | T2 CORE-1 | SPARE | - | 3000 | 3000 | 1 | X | 1000 | 1000 | 25 | 25 | 7 | 7 |
| | 6 | T2 CORE-2 | 87B (DISC ZONE) | 7SJ64+ RAEDK | 4000 | 4000 | 1 | X | 800 | NA | 25 | NA | 6 | NA |
| | 7 | T2 CORE-3 | 87B (CHK ZONE) | 7SJ64+ RAEDK | 4000 | 4000 | 1 | X | 800 | NA | 25 | NA | 6 | NA |
| SGT Bushing CTs | 1 | BCT-3 | 87C1 | 7SJ64+ RAEDK | 3000 | 3000 | 1 | X | 1000 | 1000 | 25 | 25 | 7 | 7 |
| | 2 | BCT-4 | 87C2 | REC670+ RAEDK | 3000 | 3000 | 1 | X | 1000 | 1000 | 25 | 25 | 7 | 7 |
| | 3 | BCT-7 | 64N ( Tertiary ) | 7SJ64 | 800-100 | 100 | 1 | 5P20, 15VA | | | | | | |
| | 4 | BCT-8 | 50/51+50N/ 51N ( Tertiary ) | 7SJ64 | 800-100 | 800 | 1 | 5P20, 15VA | | | | | | |

| | Sr. No | CT No | Function | Relay Type | CT Primary ( Amp) | Adopted Tap ( Amp) | CT Secondary | CT Class | CT Knee Point Voltage | CT Knee Point Voltage At Adopted | CT Magnetizing Current ( mAmp ) | CT Magnetizing Current At Selected | CT Resistance (Ohms) | CT Resistance Selected Tap (Ohms) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 132kV Bay No=D130, =D230, =D120, =D220 ( 132kV BUS SECTION & BUS COUPLER BAYS ) | 1 | T1 CORE-1 | METERING | Alpha-A3 | 4000-2000 | 2000 | 1 | 0.2FS5, 30-15VA | NA | NA | NA | NA | NA | NA |
| | 2 | T1 CORE-2 | 87B (DISC ZONE) | 7SJ64 | 4000 | 4000 | 1 | X | 800 | NA | 25 | NA | 6 | NA |
| | 6 | T2 CORE-1 | BS / BC 50/51NS + 50BF1 + 50BF2 | 7SJ64 + 7VK61 + P141 | 4000 | 4000 | 1 | X | 800 | NA | 25 | NA | 6 | NA |
| | 7 | T2 CORE-2 | 87B (CHK ZONE) | 7SJ64 | 4000 | 4000 | 1 | X | 800 | NA | 25 | NA | 6 | NA |

| **System Data** | | |
|---|---|---|
| System Fault Level, Ikmax1 | 40 | kAmp |
| Voltage Level, Vp | 132 | kV |
| System X / R Ratio | 50 | |

| **Copper Prperties** | | |
|---|---|---|
| Resitivity of Copper at 20$^{o}$C, ρ | 17.2 | nΩm |
| Temperature Coefficient of Copper, α | 0.0039 | |
| First Temperature | 20 | $^{o}$C |
| Second Temperature | 75 | $^{o}$C |
| Change in Temperature, Δt | 55 | $^{o}$C |
| | | |
| **CT Secondary Cct Cable Data For 4mm$^2$ Size** | | |
| Area of Cross Section, A | 4 | mm$^2$ |
| Length of the Conductor | 1000 | mm |
| Resistance per 1000 mm at 20$^{o}$C, $R_{20}$ = ρ x l / A | 0.0043 | Ω |
| First Teperature, T1 | 20 | $^{O}$C |
| Second Teperature, T2 | 75 | $^{O}$C |
| Difference in Temperaturwe, Δt = T2 - T1 | 55 | $^{O}$C |
| Resistance at 75$^{o}$C, $R_{75}$ = $R_{20}$ x ( 1 + α x Δt ) | 0.00522235 | Ω |

| **CT Secondary Cct Cable Data For 10mm$^2$ Size** | | |
|---|---|---|
| Area of Cross Section, A | 10 | mm$^2$ |
| Length of the Conductor | 1000 | mm |
| Resistance per 1000 mm at 20$^o$C, $R_{20}$ = ρ x l / A | 0.00172 | Ω |
| First Teperature, T1 | 20 | $^O$C |
| Second Teperature, T2 | 75 | $^O$C |
| Difference in Temperaturwe, Δt = T2 - T1 | 55 | $^O$C |
| Resistance at 75$^o$C, $R_{75}$ = $R_{20}$ x ( 1 + α x Δt ) | 0.00208894 | Ω |

| | | | |
|---|---|---|---|
| 1 | **CT Data** | | |
| | CT No | T1 CORE-4 | |
| | Function | 87C1 | |
| | Relay Type | 7SJ64+ RAEDK | |
| | CT Primary ( Amp) | 3000 | Amp |
| | Adopted Tap ( Amp) | 3000 | Amp |
| | CT Secondary | 1 | Amp |
| | CT Class | X | |
| | CT Knee Point Voltage | 1000 | Volts |
| | CT Knee Point Voltage At Adopted Tap | 1000 | Volts |
| | CT Magnetizing Current ( mAmp ) | 25 | mAmp |
| | CT Magnetizing Current At Selected Tap | 25 | mAmp |
| | CT Resistance (Ohms) | 7 | Ω |
| | CT Resistance Selected Tap (Ohms) | 7 | Ω |
| 2 | **CT Knee Point Voltage Calculation** | | |
| | CT Cable Route Length ( One Way ) | 400 | metre |
| | CT Cable Size | 4 | $mm^2$ |
| | CT Cable Resistance per metre | 0.00522235 | Ω |
| | Total CT Cable Resistance ( One Way ) | 2.08894 | Ω |
| | Maximum Secondary Through Fault Current, Ifs = Issc / Ipn | 13.333 | Amp |
| | Required Voltage Setting, Vsmin = Ifs x [ Rct + 2 x Rlead ] | 204.738 | Volts |
| | Adopted Voltage Setting = 1.2 x Vsmin | 245.686 | Volts |
| | **The CT is OK since Vk > 1.2 x Vs** | | |
| 3 | **Voltage Setting Of 7SJ64 + Series Resistance Combination** | | |
| | 7SJ64 Current Setting Range | 0.1 - 35 | Amp |
| | Selected Current Setting, Is = 0.1 x 1000 mAmp | 100 | mAmp |
| | To provide greater stability against through faults, the Voltage setting of 246 is proposed | | |
| | Hence Relay Setting Voltage, Vs | **246** | Volts |
| | The required series resistor value, Rs = Vs / Is | **2460** | Ω |
| 4 | **Shunt Resistor Calculation** | | |

| | | | |
|---|---|---|---|
| | To calculate the shunt resistor value, we have to calculate the minimum operating current of the differential scheme | | |
| | Iop = Ir + Im + Isupvn + Imet | | |
| | Where Ir = 7SJ64 operating current | 100 | mAmp |
| | Im = Magnetizing Current For CTs at Setting Voltage | 6.15 | mAmp |
| | CT Supervision Relay ( RAEDK ) Current | 5 | mAmp |
| | Imet, Metrosil Current = 0 at setting voltage | 0 | mAmp |
| | Iop = Ir + Im + Isupvn + Imet | 111.15 | mAmp |
| | As per SEC-COA practice, the primary operating current should not be less that 1.2 times the CT primary =1.2 x 3000 | 3600 | Amp |
| | Required Secondary Operating Current, Iops | 3.6 | Amp |
| | Current Through The Shunt Resistor, Ish = Iops - Iop | 3488.85 | mAmp |
| | Required Value of Shunt Resistor, Rsh = Vs / Ish | **70.51** | Ohms |
| | Required Wattage of Shunt Resistor = $Vs^2$ / Rsh | **858.26** | Watts |
| | | | |
| 5 | **Metrosil Calculation** | | |
| | The voltage developed across the relay and shunt resistor in case of an internal fault is given by, Vf = If * (Rct + 2RL + Rs) | 32949.0384 | Volts |
| | | | |
| | Vp = 2 x [ 2 x Vk x ( Vf - Vk ) ]$^{1/2}$ | 26810.0153 | |
| | Since this voltage is greater than 3000 Volts, metrosil is required | | |
| | | | |
| | Metrosil current:I (RMS), Imet = '0.52*(sqrt(2)*Vi / C)1/b | | |
| | C | 900 | |
| | ß | 0.25 | |
| | The Current Drawn By Metrosil at Setting Voltage | 5.578 | mAmp |
| | Metrosil Current is lesser than magnetizing current of the CT, and hence it is OK | | |
| | | | |
| 6 | **CT Supervision Settings** | | |
| | CT Supervision Element should operate when of of the CTs is open and there is minimum load on that feeder. We can take the minimum load to be 40% of the rated CT Primary | | |
| | Minimum load = 0.25 x CT Primary | 750 | Amp |

| | | | |
|---|---|---|---|
| | Secondary current during minimum load, Ismin | 0.25 | Amp |
| | The resultant resistance of the CT circuit during CT open conditions will be equal to the parallel combination of the shunt resistance, relay series resistance, and the CT magnetizing impedance | | |
| | Relay series resistance, Rs | 2460 | Ω |
| | Relay Shunt resistance, Rsh | 70.51 | Ω |
| | CT magnetizing imedance, Xm = Vk / Im | 142857.143 | Ω |
| | The resultant resistance 1 / R = 1 / Rs + 1 / Rsh + 1 / Xm | | |
| | R = Rs x Rsh x Xm / [ Rs x Xm + Rs x Xm + Rs x Rsh ] | 68.512 | Ω |
| | Voltage developed across the CT supervision relay = Ismin x R | 17.128 | Volts |
| | The current through the relay and series resistance cct, Ir = Vr / Rs | 0.007 | Amp |
| | Hence the CT supvn element pickup Voltage | **18** | Volts |
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|---|---|---|---|
| 1 | **CT Data** | | |
| | CT No | T1 CORE-3 | |
| | Function | 87C2 | |
| | Relay Type | REC670+ RAEDK | |
| | CT Primary ( Amp) | 3000 | Amp |
| | Adopted Tap ( Amp) | 3000 | Amp |
| | CT Secondary | 1 | Amp |
| | CT Class | X | |
| | CT Knee Point Voltage | 1000 | Volts |
| | CT Knee Point Voltage At Adopted Tap | 1000 | Volts |
| | CT Magnetizing Current ( mAmp ) | 25 | mAmp |
| | CT Magnetizing Current At Selected Tap | 25 | mAmp |
| | CT Resistance (Ohms) | 7 | Ω |
| | CT Resistance Selected Tap (Ohms) | 7 | Ω |
| 2 | **CT Knee Point Voltage Calculation** | | |
| | CT Cable Route Length ( One Way ) | 400 | metre |
| | CT Cable Size | 4 | $mm^2$ |
| | CT Cable Resistance per metre | 0.00522235 | Ω |
| | Total CT Cable Resistance ( One Way ) | 2.08894 | Ω |
| | Maximum Secondary Through Fault Current, Ifs = Issc / Ipn | 13.333 | Amp |
| | Required Voltage Setting, Vsmin = Ifs x [ Rct + 2 x Rlead ] | 149.035 | Volts |
| | Adopted Voltage Setting = 1.2 x Vsmin | **178.842** | Volts |
| | **The CT is OK since Vk > 1.2 x Vs** | | |
| 3 | **Voltage Setting Of REC670 + Series Resistance Combination** | | |
| | REC670 Current Setting Range = 0.01 x In to 25 x In | 0.01 to 25 | Amp |
| | Selected Current Setting, Is = 0.1 x 1000 mAmp | **100** | mAmp |
| | To provide greater stability against through faults, the Voltage setting of 179 is proposed | | |
| | Hence Relay Setting Voltage, Vs | 179 | Volts |
| | The required series resistor value, Rs = Vs / Is | **1790** | Ω |
| 4 | **Shunt Resistor Calculation** | | |

| | | | |
|---|---|---|---|
| | To calculate the shunt resistor value, we have to calculate the minimum operating current of the differential scheme | | |
| | Iop = Ir + Im + Isupvn + Imet | | |
| | Where Ir = REC670 operating current | 100 | mAmp |
| | Im = Magnetizing Current For CTs at Setting Voltage | 4.48 | mAmp |
| | CT Supervision Relay ( RAEDK ) Current | 5 | mAmp |
| | Imet, Metrosil Current = 0 at setting voltage | 0 | mAmp |
| | Iop = Ir + Im + Isupvn + Imet | 109.48 | mAmp |
| | As per SEC-COA practice, the primary operating current should not be less that 1.2 times the CT primary =1.2 x 3000 | 3600 | Amp |
| | Required Secondary Operating Current, Iops | 1.2 | Amp |
| | Current Through The Shunt Resistor, Ish = Iops - Iop | 1090.52 | mAmp |
| | Required Value of Shunt Resistor, Rsh = Vs / Ish | 164.14 | Ohms |
| | Required Wattage of Shunt Resistor = $Vs^2$ / Rsh | 195.21 | Watts |
| | | | |
| 5 | **Metrosil Calculation (Will be confirmed after specifying Metrosil type)** | | |
| | The voltage developed across the relay and shunt resistor in case of an internal fault is given by, Vf = If * (Rct + 2RL + Rs) | 24015.70507 | Volts |
| | | | |
| | Vp = 2 x [ 2 x Vk x ( Vf - Vk ) $]^{1/2}$ | 22458.33746 | |
| | Since this voltage is greater than 3000 Volts, metrosil is required | | |
| | | | |
| | Metrosil current:I (RMS), Imet = '0.52*(sqrt(2)*Vi / C)1/b | | |
| | C | 900 | |
| | ß | 0.25 | |
| | The Current Drawn By Metrosil at Setting Voltage | 3.253 | mAmp |
| | Metrosil Current is lesser than magnetizing current of the CT, and hence it is OK | | |
| | | | |
| 6 | **CT Supervision Settings** | | |
| | CT Supervision Element should operate when of of the CTs is open and there is minimum load on that feeder. We can take the minimum load to be 40% of the rated CT Primary | | |
| | Minimum load = 0.25 x CT Primary | 750 | Amp |
| | Secondary current during minimum load, Ismin | 0.25 | Amp |

| | | | |
|---|---|---|---|
| | The resultant resistance of the CT circuit during CT open conditions will be equal to the parallel combination of the shunt resistance, relay series resistance, and the CT magnetizing impedance | | |
| | Relay series resistance, Rs | 1790 | Ω |
| | Relay Shunt resistance, Rsh | 164.14 | Ω |
| | CT magnetizing imedance, Xm = Vk / Im | 142857.1429 | Ω |
| | CT spervision relay resistance, Rsupvn = Vs / Isupvn | 35800 | Ω |
| | The resultant resistance 1 / R = 1 / Rs + 1 / Rsh + 1 / Xm + 1 / Rsupvn | | |
| | R = [ Rs x Rsh x Xm x Rsupvn ] / [ Rsh x Xm + Xm x Rsupvn + Rsupvn x Rs + Rs x Rsh ] | 149.101 | Ω |
| | Voltage developed across the CT supervision relay = Ismin x R | 37.27525 | Volts |
| | The current through the relay and series resistance cct, Ir = Vr / Rs | 0.021 | Amp |
| | Hence the CT supvn element pickup Voltage | 38 | Volts |
| | | | |
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|---|---|---|---|
| 1 | **CT Data** | | |
| | CT No | BCT-8 | |
| | Function | 50/51+50N/51N ( Tertiary ) | |
| | Meter / Relay Type | 7SJ64 | |
| | CT Primary ( Amp) | 800-100 | Amp |
| | Adopted Tap ( Amp) | 800 | Amp |
| | CT Secondary | 1 | Amp |
| | CT Class | 5P20, 15VA | |
| | CT Resistance ( Assumed ) | 3 | Ω |
| 2 | **Tertiary Zig Zag Transformer Fault Calculation** | | |
| | Main Transformer MVA Rating | 500 | MVA |
| | % Z between HV & Tertiary Winding | 1140 | % |
| | Tertiary Winding kV rating | 13.8 | kV |
| | Maximum Ground Fault Current, If = MVA x 1000 x 100 / [ SQRT(3) x kVs x %Z ] | 1834.955 | Amp |
| 3 | **CT Minimum Required Knee Point Voltage Calculation** | | |
| | CT Cable Route Length ( One Way ) | 200 | metre |
| | CT Cable Size | 4 | $mm^2$ |
| | CT Cable Resistance per metre | 0.00522235 | Ω |
| | Total CT Cable Resistance ( One Way ) | 1.04447 | Ω |
| | Maximum Secondary Ground Fault Current, Ifs = If / Ipn | 2.29369375 | Amp |
| | Required Voltage Setting, Vsmin = Ifs x [ Rct + 2 x Rlead ] | 16.464 | Volts |
| | Adopted Voltage Setting = 1.2 x Vsmin | 19.757 | Volts |
| 4 | **CT Knee Point Estimation** | | |
| | The CT is a P class CT, Hence its adequacy will be estimated by calculating the operating accuracy limiting factor | | |
| | Where Sn = Rated VA Burden | 15 | VA |
| | In = Rated CT secondary | 1 | Amp |
| | Rct = CT Resistance ( Assumed ) | 3 | Ω |
| | Rrelay = Relay CT input Resistance | 0.05 | Ω |

| | | | |
|---|---|---|---|
| | Fn = Rated Accuracy Limiting Factor | 20 | |
| | Sin = Internal CT burden = $In^2$ x Rct | 3 | VA |
| | Sa = External CT burden = $In^2$ x [ 2 x Rlead + Rrelay ] | 2.13894 | VA |
| | Operating Accuracy Liming Factor, Fa = Fn x [ Sin + Sn ] / [ Sin + Sa ] | 70.053 | |
| | The CT is OK Since Fa > Fn | | |
| 5 | **Voltage Setting Of 7SJ64 + Series Resistance Combination** | | |
| | 7SJ64 Current Setting Range ( Using Flexible OC Protection Function 50, 0.15 / 5 to 200 / 5 in steps of 0.01 / 5 ) | 0.03 - 40 | Amp |
| | Selected Current Setting, Is = 0.1 x 1000 mAmp | 30 | mAmp |
| | To provide greater stability against through faults, the Voltage setting of 20 is proposed | | |
| | Hence Relay Setting Voltage, Vs | **20** | Volts |
| | The required series resistor value, Rs = Vs / Is | **666.67** | Ω |
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| | 1 | **CT DETAILS** | | |
| | | CT No | T1 CORE-1 | |
| | | Function | METERING | |
| | | Meter Type | Alpha-A3 | |
| | | CT Primary ( Amp) | 3000-1500 | Amp |
| | | Adopted Tap ( Amp) | 1500 | Amp |
| | | CT Secondary | 1 | Amp |
| | | CT Class | 0.2FS5, 30-15VA | |
| | | CT Resistance, Rct ( Assumed ) | 3.5 | Ω (Assumed ) |
| | 2 | **METER BURDEN DETAILS** | | |
| | | Connected Burden is the Energy Meter Alpha-A3RAQ | | |
| | | Alpha Meter CT Resistance per phase | 0.1 | milli Ohm |
| | | Meter Burden at CT Secondary Rated Current = $In^2$ x Rmeter | 0.0001 | VA |
| | 3 | **CT LEAD BURDEN** | | |
| | | Lead Length ( One Way ), L | 200 | metre |
| | | Lead Size, A | 4 | $mm^2$ |
| | | Lead Resistance per metre, rl | 0.00522235 | Ω / metre |
| | | Total Lead Resistance, RLEAD = rl x L | 1.04447 | Ω |
| | | | | |
| | 4 | **CRITERION FOR METERING CLASS CT ADEQUACY** | | |
| | | The Criterion for any P class CT used for OC/EF protection, in general is given by , Fa = Fn x [ Sin + Sn ] / [ Sin + Sa ] | | |
| | | Fn = CT Accuracy Limiting Factor at Rated Burden | 5 | |
| | | Sn = CT Rated VA Burden | 15 | VA |
| | | Sin = CT Internal Burden = $In^2$ x Rct | 3.5 | VA |
| | | Sa = CT Connected Burden = $In^2$ x [ Rlead x 2 + Rrelay ] | 2.08904 | VA |
| | | CT Accuracy Limiting Factor at Rated Burden, Fn | 5 | |
| | | Actual Accuracy Limiting Factor, Fa = Fn x [ Sin + Sn ] / [ Sin + Sa ] | 16.55 | |

| | | | | |
|---|---|---|---|---|
| | | Maximum Secondary Short Circuit Current, Issc = Maximum Primary ( 40kAmp ) / CT Primary | 26.667 | |
| | | The Actual Accuracy Limiting Factor has to be compared with the maximum secondary short circuit current, and Fa is OK if Fa < Issc | Fa IS OK | |
| | | Maximum Continuous Current for the meter | 20 | Amp |
| | | Maximum Short Duration Current = 200% of Max Continuous Current | 40 | Amp |
| | | The meter will be safe, since Fa < Maximum Short Duration Current | | |
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|---|---|---|---|
| 1 | **CT Data** | | |
| | CT No | T2 CORE-3 | |
| | Function | 87B (CHK ZONE) | |
| | Relay Type | 7SJ64 | |
| | CT Primary ( Amp) | 4000 | Amp |
| | Adopted Tap ( Amp) | 4000 | Amp |
| | CT Secondary | 1 | Amp |
| | CT Class | X | |
| | CT Knee Point Voltage | 800 | Volts |
| | CT Knee Point Voltage At Adopted Tap | NA | Volts |
| | CT Magnetizing Current ( mAmp ) | 25 | mAmp |
| | CT Magnetizing Current At Selected Tap | NA | mAmp |
| | CT Resistance (Ohms) | 6 | Ω |
| | CT Resistance Selected Tap (Ohms) | NA | Ω |
| 2 | **CT Knee Point Voltage Calculation** | | |
| | CT Cable Route Length ( One Way ) | 300 | metre |
| | CT Cable Size | 4 | $mm^2$ |
| | CT Cable Resistance per metre | 0.00522235 | Ω |
| | Total CT Cable Resistance ( One Way ) | 1.566705 | Ω |
| | Maximum Secondary Through Fault Current, Ifs = Issc / Ipn | 10 | Amp |
| | Required Voltage Setting, Vsmin = Ifs x [ Rct + 2 x Rlead ] | 122.668 | Volts |
| | Adopted Voltage Setting = 1.2 x Vsmin | 147.202 | Volts |
| | **The CT is OK since Vk > 2 x 1.2 x Vs** | | |
| | **Voltage Setting Of Micom P141 + Series Resistance Combination** | | |
| | REC670 Current Setting Range = 0.01 x In to 25 x In | 0.01 to 25 | Amp |
| | Selected Current Setting, Is = 0.1 x 1000 mAmp | **100** | mAmp |
| | To provide greater stability against through faults, the Voltage setting of 148 is proposed | | |
| | Hence Relay Setting Voltage, Vs | **148** | Volts |
| | The required series resistor value, Rs = Vs / Is | **1480** | Ω |
| 3 | **Shunt Resistor Calculation** | | |

| | | | |
|---|---|---|---|
| | To calculate the shunt resistor value, we have to calculate the minimum operating current of the differential scheme | | |
| | Iop = Ir + Im + Isupvn + Imet | | |
| | Where Ir = 7SJ64 operating current | 100 | mAmp |
| | Im = Magnetizing Current For CTs at Setting Voltage | 4.63 | mAmp |
| | CT Supervision Relay ( RAEDK ) Current | 5 | mAmp |
| | Imet, Metrosil Current = 0 at setting voltage | 0 | mAmp |
| | Iop = Ir + Im + Isupvn + Imet | 109.63 | mAmp |
| | As per SEC-COA practice, the primary operating current should not be less that 1.2 times the CT primary =1.2 x 4000 | 4800 | Amp |
| | Required Secondary Operating Current, Iops | 6 | Amp |
| | Current Through The Shunt Resistor, Ish = Iops - Iop | 5890.37 | mAmp |
| | Required Value of Shunt Resistor, Rsh = Vs / Ish | 25.13 | Ohms |
| | Required Wattage of Shunt Resistor = $Vs^2$ / Rsh | 871.63 | Watts |
| | | | |
| 4 | **Metrosil Calculation** | | |
| | The voltage developed across the relay and shunt resistor in case of an internal fault is given by, Vf = If * (Rct + 2RL + Rs) | 14891.3341 | Volts |
| | | | |
| | Vp = 2 x [ 2 x Vk x ( Vf - Vk ) $]^{1/2}$ | 9496.554019 | |
| | Since this voltage is greater than 3000 Volts, metrosil is required | | |
| | | | |
| | Metrosil current:I (RMS), Imet = '0.52*(sqrt(2)*Vi / C)1/b | | |
| | C | 900 | |
| | ß | 0.25 | |
| | The Current Drawn By Metrosil at Setting Voltage | 0.731 | mAmp |
| | **Metrosil Current is lesser than magnetizing current of the CT, and hence it is OK** | | |
| | | | |
| 5 | **CT Supervision Settings** | | |
| | CT Supervision Element should operate when of of the CTs is open and there is minimum load on that feeder. We can take the minimum load to be 40% of the rated CT Primary | | |
| | Minimum load = 0.25 x CT Primary | 1000 | Amp |
| | Secondary current during minimum load, Ismin | 0.25 | Amp |

| | | | |
|---|---|---|---|
| | The resultant resistance of the CT circuit during CT open conditions will be equal to the parallel combination of the shunt resistance, relay series resistance, and the CT magnetizing impedance | | |
| | Relay series resistance, Rs | 1480 | Ω |
| | Relay Shunt resistance, Rsh | 25.13 | Ω |
| | CT magnetizing imedance, Xm = Vk / Im | 32000 | Ω |
| | CT spervision relay resistance, Rsupvn = Vs / Isupvn | 29600 | Ω |
| | The resultant resistance 1 / R = 1 / Rs + 1 / Rsh + 1 / Xm + 1 / Rsupvn | | |
| | R = [ Rs x Rsh x Xm x Rsupvn ] / [ Rsh x Xm + Xm x Rsupvn + Rsupvn x Rs + Rs x Rsh ] | 24.669 | Ω |
| | Voltage developed across the CT supervision relay = Ismin x R | 6.16725 | Volts |
| | The current through the relay and series resistance cct, Ir = Vr / Rs | 0.004 | Amp |
| | Hence the CT supvn element pickup Voltage | 7 | Volts |
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|---|---|---|---|
| 1 | **CT Data** | | |
| | CT No | T2 CORE-3 | |
| | Function | 87B (CHK ZONE) | |
| | Relay Type | 7SJ64 | |
| | CT Primary ( Amp) | 4000 | Amp |
| | Adopted Tap ( Amp) | 4000 | Amp |
| | CT Secondary | 1 | Amp |
| | CT Class | X | |
| | CT Knee Point Voltage | 800 | Volts |
| | CT Knee Point Voltage At Adopted Tap | NA | Volts |
| | CT Magnetizing Current ( mAmp ) | 25 | mAmp |
| | CT Magnetizing Current At Selected Tap | NA | mAmp |
| | CT Resistance (Ohms) | 6 | Ω |
| | CT Resistance Selected Tap (Ohms) | NA | Ω |
| 2 | **CT Knee Point Voltage Calculation** | | |
| | CT Cable Route Length ( One Way ) | 300 | metre |
| | CT Cable Size | 4 | $mm^2$ |
| | CT Cable Resistance per metre | 0.00522235 | Ω |
| | Total CT Cable Resistance ( One Way ) | 1.566705 | Ω |
| | Maximum Secondary Through Fault Current, Ifs = Issc / Ipn | 10 | Amp |
| | Required Voltage Setting, Vsmin = Ifs x [ Rct + 2 x Rlead ] | 122.668 | Volts |
| | Adopted Voltage Setting = 1.2 x Vsmin | 147.202 | Volts |
| | **The CT is OK since Vk > 2 x 1.2 x Vs** | | |
| | **Voltage Setting Of Micom P141 + Series Resistance Combination** | | |
| | REC670 Current Setting Range = 0.01 x In to 25 x In | 0.01 to 25 | Amp |
| | Selected Current Setting, Is = 0.1 x 1000 mAmp | **100** | mAmp |
| | To provide greater stability against through faults, the Voltage setting of 148 is proposed | | |
| | Hence Relay Setting Voltage, Vs | **148** | Volts |
| | The required series resistor value, Rs = Vs / Is | **1480** | Ω |
| 3 | **Shunt Resistor Calculation** | | |

| | | | |
|---|---|---|---|
| | To calculate the shunt resistor value, we have to calculate the minimum operating current of the differential scheme | | |
| | Iop = Ir + Im + Isupvn + Imet | | |
| | Where Ir = 7SJ64 operating current | 100 | mAmp |
| | Im = Magnetizing Current For CTs at Setting Voltage | 4.63 | mAmp |
| | CT Supervision Relay ( RAEDK ) Current | 5 | mAmp |
| | Imet, Metrosil Current = 0 at setting voltage | 0 | mAmp |
| | Iop = Ir + Im + Isupvn + Imet | 109.63 | mAmp |
| | As per SEC-COA practice, the primary operating current should not be less that 1.2 times the CT primary =1.2 x 4000 | 4800 | Amp |
| | Required Secondary Operating Current, Iops | 6 | Amp |
| | Current Through The Shunt Resistor, Ish = Iops - Iop | 5890.37 | mAmp |
| | Required Value of Shunt Resistor, Rsh = Vs / Ish | 25.13 | Ohms |
| | Required Wattage of Shunt Resistor = $Vs^2$ / Rsh | 871.63 | Watts |
| | | | |
| 4 | **Metrosil Calculation** | | |
| | The voltage developed across the relay and shunt resistor in case of an internal fault is given by, Vf = If * (Rct + 2RL + Rs) | 14891.3341 | Volts |
| | | | |
| | Vp = 2 x [ 2 x Vk x ( Vf - Vk ) $]^{1/2}$ | 9496.554019 | |
| | Since this voltage is greater than 3000 Volts, metrosil is required | | |
| | | | |
| | Metrosil current:I (RMS), Imet = '0.52*(sqrt(2)*Vi / C)1/b | | |
| | C | 900 | |
| | ß | 0.25 | |
| | The Current Drawn By Metrosil at Setting Voltage | 0.731 | mAmp |
| | **Metrosil Current is lesser than magnetizing current of the CT, and hence it is OK** | | |
| | | | |
| 5 | **CT Supervision Settings** | | |
| | CT Supervision Element should operate when of of the CTs is open and there is minimum load on that feeder. We can take the minimum load to be 40% of the rated CT Primary | | |
| | Minimum load = 0.25 x CT Primary | 1000 | Amp |
| | Secondary current during minimum load, Ismin | 0.25 | Amp |

| | | | |
|---|---|---|---|
| | The resultant resistance of the CT circuit during CT open conditions will be equal to the parallel combination of the shunt resistance, relay series resistance, and the CT magnetizing impedance | | |
| | Relay series resistance, Rs | 1480 | Ω |
| | Relay Shunt resistance, Rsh | 25.13 | Ω |
| | CT magnetizing imedance, Xm = Vk / Im | 32000 | Ω |
| | CT spervision relay resistance, Rsupvn = Vs / Isupvn | 29600 | Ω |
| | The resultant resistance 1 / R = 1 / Rs + 1 / Rsh + 1 / Xm + 1 / Rsupvn | | |
| | R = [ Rs x Rsh x Xm x Rsupvn ] / [ Rsh x Xm + Xm x Rsupvn + Rsupvn x Rs + Rs x Rsh ] | 24.669 | Ω |
| | Voltage developed across the CT supervision relay = Ismin x R | 6.16725 | Volts |
| | The current through the relay and series resistance cct, Ir = Vr / Rs | 0.004 | Amp |
| | Hence the CT supvn element pickup Voltage | 7 | Volts |
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| 1 | **CT Data** | | |
| | CT No | T1 CORE-2 | |
| | Function | MAIN-1 PROTN (BOX-1) | |
| | Relay Type | 7UT6 | |
| | CT Primary ( Amp) | 300 | Amp |
| | Adopted Tap ( Amp) | 300 | Amp |
| | CT Secondary | 1 | Amp |
| | CT Class | X | |
| | CT Knee Point Voltage | 360 | Volts |
| | CT Knee Point Voltage At Adopted Tap | 360 | Volts |
| | CT Magnetizing Current ( mAmp ) | 50 | mAmp |
| | CT Magnetizing Current At Selected Tap | 50 | mAmp |
| | CT Resistance (Ohms) | 1 | Ω |
| | CT Resistance Selected Tap (Ohms) | 1 | Ω |
| | **CT Knee Point Voltage Calculation** | | |
| 2 | **Lead Burden** | | |
| | CT Cable Route Length ( One Way ) | 200 | metre |
| | CT Cable Size | 4 | $mm^2$ |
| | CT Cable Resistance per metre | 0.00522235 | Ω |
| | Total CT Cable Resistance ( One Way ) | 1.04447 | Ω |
| 3 | **Relay Burden** | | |
| | VA Burden of 7UT6 CT Input | 0.02 | VA |
| | Rated Secondary Current, In | 1 | Amp |
| | Relay CT Input Resistance = VA / $In^2$ | 0.02 | Ω |
| 4 | **CT Stability Criterion** | | |
| | The required knee point voltage of the CT Is given by, Vk = Ktd x Isscmax x ( Rct + 2 x Rlead + Rrelay ) x Isn / 1.3 x Ipn | | |
| | The maximum external fault current is limited by the %Z of the transformer and given by Isscmax = MVA (TF) x 1000 x 100 / (SQRT(3) x kV x %Z) | | |
| | 132/13.8kV GT MVA Rating | 60 | MVA |
| | Grid Transformer % Impedance, %Z | 10 | % |

| | | | |
|---|---|---|---|
| | Grid Transformer HV Side Voltage, kV | 132 | kV |
| | Isscmax = MVA (TF) x 1000 x 100 / (SQRT(3) x kV x %Z) | 2624.32 | Amp |
| | CT Over Dimensioning Factor for 7UT612, Ktd | 4 | |
| | The required knee point voltage, Vk = Ktd x Isscmax x ( Rct + 2 x Rlead + Rrelay ) x Isn / 1.3 x Ipn | 83.681 | Volts |
| | CT Actual Knee point Voltage, Vk | 360 | Volts |
| | Hence the CT Knee Point Voltage is OK | | |
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|---|---|---|---|
| 1 | **CT Data** | | |
| | CT No | T1 CORE-3 | |
| | Function | MAIN-2 PROTN (BOX-2) | |
| | Relay Type | RET670 | |
| | CT Primary ( Amp) | 300 | Amp |
| | Adopted Tap ( Amp) | 300 | Amp |
| | CT Secondary | 1 | Amp |
| | CT Class | X | |
| | CT Knee Point Voltage | 360 | Volts |
| | CT Knee Point Voltage At Adopted Tap | 360 | Volts |
| | CT Magnetizing Current ( mAmp ) | 50 | mAmp |
| | CT Magnetizing Current At Selected Tap | 50 | mAmp |
| | CT Resistance (Ohms) | 1 | Ω |
| | CT Resistance Selected Tap (Ohms) | 1 | Ω |
| | **CT Knee Point Voltage Calculation** | | |
| 2 | **Lead Burden** | | |
| | CT Cable Route Length ( One Way ) | 200 | metre |
| | CT Cable Size | 4 | $mm^2$ |
| | CT Cable Resistance per metre | 0.00522235 | Ω |
| | Total CT Cable Resistance ( One Way ) | 1.04447 | Ω |
| 3 | **Relay Burden** | | |
| | VA Burden of RET670 CT Input | 0.02 | VA |
| | Rated Secondary Current, In | 1 | Amp |
| | Relay CT Input Resistance = VA / $In^2$ | 0.02 | Ω |
| 4 | **CT Stability Criterion** | | |
| | There arae two criterion for estimating the minimum requirement for CT Knee Point Voltage | | |
| | **Criterion No.1**, Vk = 30 x Int x (Isn/ Ipn) x [ Rct + 2 x Rlead + Rrelay ], Where, Int = transformer rated current, Ipn = CT Primary rated Current, & Isn = CT Secondary rated current | | |
| | **Criterion No.2**, Vk = 2 x Itf x ( Isn / Ipn ) x [ Rct + 2 x Rlead + Rrelay ], Where, Itf = transformer through fault current | | |

| | | | |
|---|---|---|---|
| | The maximum external ( through ) fault current is limited by the %Z of the transformer and given by Itf = MVA (TF) x 1000 x 100 / (SQRT(3) x kV x %Z) | | |
| | 132/13.8kV GT MVA Rating | 60 | MVA |
| | Grid Transformer % Impedance, %Z | 10 | % |
| | Grid Transformer HV Side Voltage, kV | 132 | kV |
| | Itf = MVA (TF) x 1000 x 100 / (SQRT(3) x kV x %Z) | 2624.32 | Amp |
| | Transformer rated current, Itn = MVA (TF) x 1000 / (SQRT(3) x kV ) | 262.432 | Amp |
| | Knee point voltage as per **criterion No.1**, Vk = 30 x Int x (Isn/ Ipn) x [ Rct + 2 x Rlead + Rrelay ] | 81.589 | Volts |
| | Knee point voltage as per **criterion No.1**, Vk = 2 x Itf x (Isn/ Ipn) x [ Rct + 2 x Rlead + Rrelay ] | 54.392 | |
| | The required knee point = max ( Criterion No.1 , Criterion No.2 ) | 81.589 | Volts |
| | CT Actual Knee Point Voltage | 360 | Volts |
| | Hence the CT Knee Point Voltage is OK | | |
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|---|---|---|---|
| 1 | **CT DETAILS** | | |
| | CT No | T2 CORE-1 | |
| | Function | METERING | |
| | Relay Type | - | |
| | CT Primary ( Amp) | 3000-2500-2000-1600-1200-1000 | Amp |
| | Adopted Tap ( Amp) | 1000 | Amp |
| | CT Secondary | 1 | Amp |
| | CT Class | X | |
| | CT Knee Point Voltage | 4200-3500-2800-2240-1680-1400 | Volts |
| | CT Knee Point Voltage At Adopted Tap | 1400 | Volts |
| | CT Magnetizing Current ( mAmp ) | 8.33-10-12.5-15.6-20.8-25 | mAmp |
| | CT Magnetizing Current At Selected Tap | 25 | mAmp |
| | CT Resistance (Ohms) | 6-5-3.2-2.4-2 | Ω |
| | CT Resistance Selected Tap (Ohms) | 2 | Ω |
| 2 | **RELAY BURDEN DETAILS** | | |
| | Connected Burden | | |
| | 50CBF Relay 7SJ64 Burden | 0.05 | VA |
| | Alpha Meter CT Resistance per phase | 0.1 | milli Ohm |
| | Alpha Meter CT Burden per phase | 0.0001 | VA |
| | Total Device Burden | 0.0501 | VA |
| 3 | **CT LEAD BURDEN** | | |
| | Lead Length ( One Way ), L | 200 | metre |
| | Lead  Size, A | 4 | $mm^2$ |
| | Lead Resistance per metre, rl | 0.00522235 | Ω / metre |
| | Total Lead Resistance, RLEAD = rl x L | 1.04447 | Ω |
| | | | |
| 4 | **CRITERION FOR METERING CLASS CT ADEQUACY** | | |

| | | | |
|---|---|---|---|
| | Class X CT is used for metering here, directly. To check that meter will be secure or not, class X parameters have to be converted into equivalent P class CT. | | |
| | The CT Vk, VA burden & accuracy limiting factors are related by, Vk = Fn x In x [ Rct + Sn / $In^2$ ] / 1.3 | | |
| | **OR** | | |
| | Sn = [ 1.3 x Vk - Fn x In x Rct ] x In / Fn | | |
| | Fn = CT Accuracy Limiting Factor at Rated Burden | 20 | |
| | Sn = [ 1.3 x Vk - Fn x In x Rct ] x In / Fn | 89 | |
| | The Criterion for any P class CT , in general is given by , **Fa = Fn x [ Sin + Sn ] / [ Sin + Sa ]** | | |
| | Sin = CT Internal Burden = $In^2$ x Rct | 2 | VA |
| | Sa = CT Connected Burden = $In^2$ x [ Rlead x 2 + Rrelay ] | 2.13904 | VA |
| | CT Accuracy Limiting Factor at Rated Burden, Fn | 20 | |
| | Actual Accuracy Limiting Factor, Fa = Fn x [ Sin + Sn ] / [ Sin + Sa ] | 439.72 | |
| | Maximum Secondary Short Circuit Current, Issc = Maximum Primary ( 40kAmp ) / CT Primary | 100 | Amp |
| | Maximum Continuous Current for the meter | 20 | Amp |
| | Maximum Short Duration Current = 200% of Max Continuous Current | 40 | Amp |
| | The Actual Accuracy Limiting Factor has to be compared with the maximum 1 second instrument current, and Fa is OK if Is x Fa < Imeter(1sec) | Fa Not OK | |
| | **Hence it is proposed to use IPCT with the meter** | | |
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|---|---|---|---|
| 1 | **CT DETAILS** | | |
| | CT No | T2 CORE-1 | |
| | Function | METERING | |
| | Relay Type | - | |
| | CT Primary ( Amp) | 1600-1200-800-600 | Amp |
| | Adopted Tap ( Amp) | 800 | Amp |
| | CT Secondary | 1 | Amp |
| | CT Class | X | |
| | CT Knee Point Voltage | 2800-2100-1400-1050 | Volts |
| | CT Knee Point Voltage At Adopted Tap | 1400 | Volts |
| | CT Magnetizing Current ( mAmp ) | 12.5-16.7-25-33.3 | mAmp |
| | CT Magnetizing Current At Selected Tap | 25 | mAmp |
| | CT Resistance (Ohms) | 4-3-2-1.5 | Ω |
| | CT Resistance Selected Tap (Ohms) | 2 | Ω |
| 2 | **RELAY BURDEN DETAILS** | | |
| | Connected Burden | | |
| | 50CBF Relay 7SJ64 Burden | 0.05 | VA |
| | Alpha Meter CT Resistance per phase | 0.1 | milli Ohm |
| | Alpha Meter CT Burden per phase | 0.0001 | VA |
| | Total Device Burden | 0.0501 | VA |
| 3 | **CT LEAD BURDEN** | | |
| | Lead Length ( One Way ), L | 200 | metre |
| | Lead Size, A | 4 | $mm^2$ |
| | Lead Resistance per metre, rl | 0.00522235 | Ω / metre |
| | Total Lead Resistance, RLEAD = rl x L | 1.04447 | Ω |
| | | | |
| 4 | **CRITERION FOR METERING CLASS CT ADEQUACY** | | |

| | | | |
|---|---|---|---|
| | Class X CT is used for metering here, directly. To check that meter will be secure or not, class X parameters have to be converted into equivalent P class CT. | | |
| | The CT Vk, VA burden & accuracy limiting factors are related by, Vk = Fn x In x [ Rct + Sn / $In^2$ ] / 1.3 | | |
| | **OR** | | |
| | Sn = [ 1.3 x Vk - Fn x In x Rct ] x In / Fn | | |
| | Fn = CT Accuracy Limiting Factor at Rated Burden | 20 | |
| | Sn = [ 1.3 x Vk - Fn x In x Rct ] x In / Fn | 89 | |
| | The Criterion for any P class CT , in general is given by , **Fa = Fn x [ Sin + Sn ] / [ Sin + Sa ]** | | |
| | Sin = CT Internal Burden = $In^2$ x Rct | 2 | VA |
| | Sa = CT Connected Burden = $In^2$ x [ Rlead x 2 + Rrelay ] | 2.13904 | VA |
| | CT Accuracy Limiting Factor at Rated Burden, Fn | 20 | |
| | Actual Accuracy Limiting Factor, Fa = Fn x [ Sin + Sn ] / [ Sin + Sa ] | 439.72 | |
| | Maximum Secondary Short Circuit Current, Issc = Maximum Primary ( 40kAmp ) / CT Primary | 100 | Amp |
| | Maximum Continuous Current for the meter | 20 | Amp |
| | Maximum Short Duration Current = 200% of Max Continuous Current | 40 | Amp |
| | The Actual Accuracy Limiting Factor has to be compared with the maximum 1 second instrument current, and Fa is OK if Is x Fa < Imeter(1sec) | Fa Not OK | |
| | **Hence it is proposed to use IPCT with the meter** | | |

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|---|---|---|---|
| 1 | **CT Data ( Reactor Bay =D21 & =D26 )** | | |
| | CT No | T1 CORE-3 | & Reactor Bushing CT LC1-2 |
| | Function | 87C | |
| | Relay Type | 7SJ64 | |
| | CT Primary ( Amp) | 1200-600-400-200 | Amp |
| | Adopted Tap ( Amp) | 1200 | Amp |
| | CT Secondary | 1 | Amp |
| | CT Class | X | |
| | CT Knee Point Voltage | 2400-1200-800-400 | Volts |
| | CT Knee Point Voltage At Adopted Tap | 2400 | Volts |
| | CT Magnetizing Current ( mAmp ) | 8.33-16.7-25-50 | mAmP |
| | CT Magnetizing Current At Selected Tap | 8.33 | mAmP |
| | CT Resistance (Ohms) | 6-3-2-1 | Ω |
| | CT Resistance Selected Tap (Ohms) | 6 | Ω |
| 2 | **CT Knee Point Voltage Calculation** | | |
| | CT Cable Route Length ( One Way ) | 400 | metre |
| | CT Cable Size | 10 | $mm^2$ |
| | CT Cable Resistance per metre | 0.00208894 | Ω |
| | Total CT Cable Resistance ( One Way ) | 0.835576 | Ω |
| | Maximum Secondary Through Fault Current, Ifs = Issc / Ipn | 33.3333333 | Amp |
| | Required Voltage Setting, Vsmin = Ifs x [ Rct + 2 x Rlead ] | 311.41 | Volts |
| | Adopted Voltage Setting = 1.2 x Vsmin | 373.692 | Volts |
| | **The CT is OK since Vk > 1.2 x Vs** | | |
| 3 | **Voltage Setting Of 7SJ64 + Series Resistance Combination** | | |
| | 7SJ64 Current Setting Range | 0.1 - 35 | Amp |
| | Selected Current Setting, Is = 0.1 x 1000 mAmp | 100 | mAmp |
| | To provide greater stability against through faults, the Voltage setting of 374 is proposed | | |
| | Hence Relay Setting Voltage, Vs | **374** | Volts |

| | | | |
|---|---|---|---|
| | The required series resistor value, Rs = Vs / Is | **3740** | Ω |
| 4 | **Shunt Resistor Calculation** | | |
| | To calculate the shunt resistor value, we have to calculate the minimum operating current of the differential scheme | | |
| | Iop = Ir + Im + Isupvn + Imet | | |
| | Where Ir = 7SJ64 operating current | 100 | mAmp |
| | Im = Magnetizing Current For CTs at Setting Voltage | 1.3 | mAmp |
| | CT Supervision Relay ( RAEDK ) Current | 5 | mAmp |
| | Imet, Metrosil Current = 0 at setting voltage | 0 | mAmp |
| | Iop = Ir + Im + Isupvn + Imet | 106.3 | mAmp |
| | As per SEC-COA practice, the primary operating current should not be less that 1.2 times the CT primary =1.2 x 3000 | 1440 | Amp |
| | Required Secondary Operating Current, Iops | 0.6 | Amp |
| | Current Through The Shunt Resistor, Ish = Iops - Iop | 493.7 | mAmp |
| | Required Value of Shunt Resistor, Rsh = Vs / Ish | **757.55** | Ohms |
| | Required Wattage of Shunt Resistor = $Vs^2$ / Rsh | **184.64** | Watts |
| | | | |
| 5 | **Metrosil Calculation** | | |
| | The voltage developed across the relay and shunt resistor in case of an internal fault is given by, Vf = If * (Rct + 2RL + Rs) | 124922.372 | Volts |
| | | | |
| | Vp = 2 x [ 2 x Vk x ( Vf - Vk ) ]$^{1/2}$ | 34463.5281 | |
| | Since this voltage is greater than 3000 Volts, metrosil is required | | |
| | | | |
| | Metrosil current:I (RMS), Imet = '0.52*(sqrt(2)*Vi / C)1/b | | |
| | C | 900 | |
| | ß | 0.25 | |
| | The Current Drawn By Metrosil at Setting Voltage | 29.803 | mAmp |
| | Metrosil Current is lesser than magnetizing current of the CT, and hence it is OK | | |
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| 6 | **CT Supervision Settings** | | |

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| | CT Supervision Element should operate when of of the CTs is open and there is minimum load on that feeder. We can take the minimum load to be 40% of the rated CT Primary | | |
| | Minimum load = 0.25 x CT Primary | 300 | Amp |
| | Secondary current during minimum load, Ismin | 0.25 | Amp |
| | The resultant resistance of the CT circuit during CT open conditions will be equal to the parallel combination of the shunt resistance, relay series resistance, and the CT magnetizing impedance | | |
| | Relay series resistance, Rs | 3740 | Ω |
| | Relay Shunt resistance, Rsh | 757.55 | Ω |
| | CT magnetizing imedance, Xm = Vk / Im | 288.115246 | Ω |
| | The resultant resistance 1 / R = 1 / Rs + 1 / Rsh + 1 / Xm | | |
| | R = Rs x Rsh x Xm / [ Rs x Xm + Rs x Xm + Rs x Rsh ] | 197.697 | Ω |
| | Voltage developed across the CT supervision relay = Ismin x R | 49.42425 | Volts |
| | The current through the relay and series resistance cct, Ir = Vr / Rs | 0.013 | Amp |
| | Hence the CT supvn element pickup Voltage | **50** | Volts |
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| 1 | **CT DETAILS** | | |
| | CT No | T1 CORE-2 | |
| | Function | 50/51N + 50BF | |
| | Meter / Relay Type | 7SJ64 | |
| | CT Primary ( Amp) | 1200-600-400-200 | Amp |
| | Adopted Tap ( Amp) | 200 | Amp |
| | CT Secondary | 1 | Amp |
| | CT Class | X | |
| | CT Knee Point Voltage | 2400-1200-800-400 | Volts |
| | CT Knee Point Voltage At Adopted Tap | 400 | Volts |
| | CT Magnetizing Current ( mAmp ) | 8.33-16.7-25-50 | mAmP |
| | CT Magnetizing Current At Selected Tap | 50 | mAmP |
| | CT Resistance (Ohms) | 6-3-2-1 | Ω |
| | CT Resistance Selected Tap (Ohms) | 1 | Ω |
| 2 | **RELAY BURDEN DETAILS** | | |
| | Connected Burden | | |
| | Reactor OC/EF Relay 7SJ64 Burden | 0.05 | VA |
| | Total Device Burden | 0.05 | VA |
| 3 | **CT LEAD BURDEN** | | |
| | Lead Length ( One Way ), L | 200 | metre |
| | Lead Size, A | 4 | $mm^2$ |
| | Lead Resistance per metre, rl | 0.00522235 | Ω / metre |
| | Total Lead Resistance, RLEAD = rl x L | 1.04447 | Ω |
| | | | |
| 4 | **CRITERION FOR OC/EF RELAY 7SJ64** | | |
| | The OC/EF + 50BF relay 7SJ64 is connected to class X CT. Its equivalent P class CT parameters are calculated by the formula, Sn = [ 1.3 x Vk - Fn x In x Rct ] x In / Fn, Where | | |
| | Fn = CT Accuracy Limiting Factor at Rated Burden | 20 | |

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|---|---|---|---|
| | Sn = CT Rated VA Burden = = [ 1.3 x Vk - Fn x In x Rct ] x In / Fn | #VALUE! | |
| | The Criterion for any P class CT used for OC/EF protection, in general is given by , Fa = Fn x [ Sin + Sn ] / [ Sin + Sa ] | | |
| | Fn = CT Accuracy Limiting Factor at Rated Burden | 20 | |
| | | | |
| | Sin = CT Internal Burden = In2 x Rct | #VALUE! | VA |
| | Sa = CT Connected Burden = $In^2$ x [ Rlead x 2 + Rrelay ] | 2.13894 | VA |
| | CT Accuracy Limiting Factor at Rated Burden, Fn | 20 | |
| | Actual Accuracy Limiting Factor, Fa = Fn x [ Sin + Sn ] / [ Sin + Sa ] | #VALUE! | |
| | Maximum Secondary Short Circuit Current, Issc = Maximum Primary ( 40kAmp ) / CT Primary | #VALUE! | |
| | The Actual Accuracy Limiting Factor has to be compared with the maximum secondary short circuit current, and Fa is OK if Fa > $I_{HIGHSET}$ | #VALUE! | |
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| 1 | **CT Data ( Reactor Bay =D21 & =D26 )** | | |
| | CT No | LC1-1 | & NC2-1 |
| | Function | 87R | |
| | Relay Type | REC670 | |
| | CT Primary ( Amp) | 600-400-200 | Amp |
| | Adopted Tap ( Amp) | 200 | Amp |
| | CT Secondary | 1 | Amp |
| | CT Class | X | |
| | CT Knee Point Voltage | NOT AVILABLE | Volts |
| | CT Knee Point Voltage At Adopted Tap | 400 | Volts |
| | CT Magnetizing Current ( mAmp ) | NOT AVILABLE | mAmP |
| | CT Magnetizing Current At Selected Tap | 52 | mAmP |
| | CT Resistance (Ohms) | NOT AVILABLE | Ω |
| | CT Resistance Selected Tap (Ohms) | 1 | Ω |
| | **CT Cable Resistance Calculation** | | |
| | CT Cable Route Length ( One Way ) | 400 | metre |
| | CT Cable Size | 4 | $mm^2$ |
| | CT Cable Resistance per metre | 0.00522235 | Ω |
| | Total CT Cable Resistance ( One Way ) | 2.08894 | Ω |
| 2 | **Reactor Through Fault Current Calculation** | | |
| | Reactor MVAR rating | 40 | MVAR |
| | Reactor Voltage Rating, kV | 132 | kV |
| | Reactor Through Current, Itr = 1000 x MVA / [ SQRT(3) x kV ] | 174.955 | Amp |
| | Reactor CT Secondary Through Current, Itrs = Itr / CT Primary | 0.874775 | Amp |
| | Required Voltage Setting, Vsmin = Itrs x [ Rct + 2 x Rlead ] | 306.097 | Volts |
| | Adopted Voltage Setting = 1.2 x Vsmin | 367.32 | Volts |
| | **The CT is OK since Vk (400V) > 1.2 x Vs (367.32V)** | | |
| 3 | **Voltage Setting Of REC670 + Series Resistance Combination** | | |
| | REC670 Current Setting Range = 0.01 x In to 25 x In | 0.01 to 25 | Amp |
| | Selected Current Setting, Is = 0.1 x 1000 mAmp | 100 | mAmp |

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| | To provide greater stability against through faults, the Voltage setting of 368 is proposed | | |
| | Hence Relay Setting Voltage, Vs | 368 | Volts |
| | The required series resistor value, Rs = Vs / Is | **3680** | Ω |
| 4 | **Shunt Resistor Calculation** | | |
| | To calculate the shunt resistor value, we have to calculate the minimum operating current of the differential scheme | | |
| | Iop = Ir + Im + Isupvn + Imet | | |
| | Where Ir = REC670 operating current | 100 | mAmp |
| | Im = Magnetizing Current For CTs at Setting Voltage | 47.84 | mAmp |
| | CT Supervision Relay ( RAEDK ) Current | 5 | mAmp |
| | Imet, Metrosil Current = 0 at setting voltage | 0 | mAmp |
| | Iop = Ir + Im + Isupvn + Imet | 152.84 | mAmp |
| | As per SEC-COA practice, the primary operating current should not be less that 1.2 times the CT primary =1.2 x 200 | 240 | Amp |
| | Required Secondary Operating Current, Iops | 1.2 | Amp |
| | Current Through The Shunt Resistor, Ish = Iops - Iop | 1047.16 | mAmp |
| | Required Value of Shunt Resistor, Rsh = Vs / Ish | **351.43** | Ohms |
| | Required Wattage of Shunt Resistor = $Vs^2$ / Rsh | **385.35** | Watts |
| 5 | **CT Supervision Settings** | | |
| | CT Supervision Element should operate when of of the CTs is open and there is minimum load on that feeder. For Reactor, we take the minimum load to be 100% of the rated CT Primary | | |
| | Minimum load = Reactor Rated Load | 174.955 | Amp |
| | Secondary current during minimum load, Ismin | 0.874775 | Amp |
| | The resultant resistance of the CT circuit during CT open conditions will be equal to the parallel combination of the shunt resistance, relay series resistance, and the CT magnetizing impedance | | |
| | Relay series resistance, Rs | 3680 | Ω |
| | Relay Shunt resistance, Rsh | 351.43 | Ω |
| | CT magnetizing imedance, Xm = Vk / Im | 7.69230769 | Ω |
| | The resultant resistance 1 / R = 1 / Rs + 1 / Rsh + 1 / Xm | | |
| | R = Rs x Rsh x Xm / [ Rs x Xm + Rs x Xm + Rs x Rsh ] | 7.512 | Ω |

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| | Voltage developed across the CT supervision relay = Ismin x R | 6.5713098 | Volts |
| | The current through the relay and series resistance cct, Ir = Vr / Rs | 0.002 | Amp |
| | Hence the CT supvn element pickup Voltage | **7** | Volts |
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| 1 | **CT DETAILS** | | |
| | CT No | NC2-2 | |
| | Function | 51NR | |
| | Relay Type | 7SJ64 | |
| | CT Primary ( Amp) | 400 | Amp |
| | Adopted Tap ( Amp) | 400 | Amp |
| | CT Secondary | 1 | Amp |
| | CT Class | 5P20, 15VA | |
| | CT Resistance ( Assumed ) | 2 | Ω |
| 2 | **RELAY BURDEN DETAILS** | | |
| | Connected Burden | | |
| | Reactor 51NR Relay 7SJ64 Burden | 0.05 | VA |
| | Total Device Burden | 0.05 | VA |
| 3 | **CT LEAD BURDEN** | | |
| | Lead Length ( One Way ), L | 200 | metre |
| | Lead Size, A | 4 | $mm^2$ |
| | Lead Resistance per metre, rl | 0.00522235 | Ω / metre |
| | Total Lead Resistance, RLEAD = rl x L | 1.04447 | Ω |
| 4 | **CRITERION FOR OC/EF RELAY 7SJ64** | | |
| | The Criterion for any P class CT used for OC protection, in general is given by , Fa = Fn x [ Sin + Sn ] / [ Sin + Sa ] | | |
| | Fn = CT Accuracy Limiting Factor at Rated Burden | 20 | |
| | Sin = CT Internal Burden = $In^2$ x Rct | 2 | VA |
| | Sn = CT Rated Burden | 15 | Va |
| | Sa = CT Connected Burden = $In^2$ x [ Rlead x 2 + Rrelay ] | 2.13894 | VA |
| | CT Accuracy Limiting Factor at Rated Burden, Fn | 20 | |
| | Actual Accuracy Limiting Factor, Fa = Fn x [ Sin + Sn ] / [ Sin + Sa ] | 82.147 | |
| | Maximum Neutral Current = Reactor Rated Current | 0.874775 | Amp |

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| | The Actual Accuracy Limiting Factor has to be compared with the maximum secondary short circuit current, and Fa is OK if Fa > $I_{max}$ | Fa IS OK | |
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| 1 | **CT DETAILS** | | |
| | CT No | T1 CORE-1 | |
| | Function | FR + METERING +CBF1,2 | |
| | Relay Type | 7VK61 + P141 | |
| | CT Primary ( Amp) | 1200-600-400-200 | Amp |
| | Adopted Tap ( Amp) | 200 | Amp |
| | CT Secondary | 1 | Amp |
| | CT Class | X | |
| | CT Knee Point Voltage | 2400-1200-800-400 | Volts |
| | CT Knee Point Voltage At Adopted Tap | 400 | Volts |
| | CT Magnetizing Current ( mAmp ) | 8.33-16.7-25-50 | mAmp |
| | CT Magnetizing Current At Selected Tap | 50 | mAmp |
| | CT Resistance (Ohms) | 6-3-2-1 | Ω |
| | CT Resistance Selected Tap (Ohms) | 1 | Ω |
| 2 | **DEVICE BURDEN DETAILS** | | |
| | Connected Burden | | |
| | Alpha Meter CT Resistance per phase | 0.1 | milli Ohm |
| | Alpha Meter CT Burden per phase | 0.0001 | VA |
| | Fault Recorder Hathaway ( Assumed ) Burden | 0.05 | VA |
| | 50CBF1 Relay 7VK61 Burden | 0.05 | VA |
| | 50CBF2 Relay Micom P141 Burden | 0.04 | VA |
| | Total Device Burden | 0.1401 | VA |
| 3 | **CT LEAD BURDEN** | | |
| | Lead Length ( One Way ), L | 250 | metre |
| | Lead Size, A | **10** | $mm^2$ |
| | Lead Resistance per metre, rl | 0.00208894 | Ω / metre |
| | Total Lead Resistance, RLEAD = rl x L | 0.522235 | Ω |

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| 4 | **SIEMENS RELAY 7VK61** | | |
| | The CT Vk > Ipickup x [ Rct + Rrelay + 2 x Rlead ] / 1.3 | | |
| | Where $I_{HIGHSET}$ = Maximum Secondary Fault Current | 200 | Amp |
| | Vk > Ipickup x [ Rct + Rrelay + 2 x Rlead ] / 1.3 | 336.088 | Volts |
| | **Vk (400V) > 336V** | OK | |
| 5 | **AREVA RELAY P141** | | |
| | As per Manual Recommendations, 5P10, 10VA CT is OK. | | |
| | The offered CT is class PX, with high knee point voltage, must be adequate with P141 | | |
| 6 | **CRITERION FOR METERING CLASS CT ADEQUACY** | | |
| | Class X CT is used for metering here, directly. To check that meter will be secure or not, class X parameters have to be converted into equivalent P class CT. | | |
| | The CT Vk, VA burden & accuracy limiting factors are related by, Vk = Fn x In x [ Rct + Sn / $In^2$ ] / 1.3 | | |
| | **OR** | | |
| | Sn = [ 1.3 x Vk - Fn x In x Rct ] x In / Fn | | |
| | Fn = CT Accuracy Limiting Factor at Rated Burden | 20 | |
| | Sn = [ 1.3 x Vk - Fn x In x Rct ] x In / Fn | 25 | |
| | The Criterion for any P class CT used for metering, in general is given by , **Fa = Fn x [ Sin + Sn ] / [ Sin + Sa ]** | | |
| | Sin = CT Internal Burden = $In^2$ x Rct | 1 | VA |
| | Sa = CT Connected Burden = $In^2$ x [ Rlead x 2 + Rrelay ] | 1.18457 | VA |
| | CT Accuracy Limiting Factor at Rated Burden, Fn | 20 | |
| | Actual Accuracy Limiting Factor, Fa = Fn x [ Sin + Sn ] / [ Sin + Sa ] | 238.03 | |
| | Maximum Secondary Short Circuit Current, Issc = Maximum Primary ( 40kAmp ) / CT Primary | 200 | Amp |
| | Maximum Continuous Current for the meter | 20 | Amp |
| | Maximum Short Duration Current = 200% of Max Continuous Current | 40 | Amp |
| | The Actual Accuracy Limiting Factor has to be compared with the maximum 1 second instrument current, and Fa is OK if Is x Fa < Imeter(1sec) | Fa Not OK | |
| | **Hence, IPCT must be used (1/1A, 0.2Fs5, 5VA, 2 Ohm)** | | |

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| 1 | **CT DETAILS** | | |
| | CT No | T2 CORE-1 | |
| | Function | BS / BC 50/51NS + 50BF1 + 50BF2 | |
| | Meter / Relay Type | 7SJ64 + 7VK61 + P141 | |
| | CT Primary ( Amp) | 4000 | Amp |
| | Adopted Tap ( Amp) | 4000 | Amp |
| | CT Secondary | 1 | Amp |
| | CT Class | X | |
| | CT Knee Point Voltage | 800 | Volts |
| | CT Knee Point Voltage At Adopted Tap | NA | Volts |
| | CT Magnetizing Current ( mAmp ) | 25 | mAmP |
| | CT Magnetizing Current At Selected Tap | NA | mAmP |
| | CT Resistance (Ohms) | 6 | Ω |
| | CT Resistance Selected Tap (Ohms) | NA | Ω |
| 2 | **RELAY BURDEN DETAILS** | | |
| | Connected Burden | | |
| | Reactor OC/EF Relay 7SJ64 Burden | 0.05 | VA |
| | 50CBF1 Relay 7VK61 Burden | 0.05 | VA |
| | 50CBF2 Relay Micom P141 Burden | 0.04 | VA |
| | Total Device Burden | 0.14 | VA |
| 3 | **CT LEAD BURDEN** | | |
| | Lead Length ( One Way ), L | 150 | metre |
| | Lead Size, A | 4 | $mm^2$ |
| | Lead Resistance per metre, rl | 0.00522235 | Ω / metre |
| | Total Lead Resistance, RLEAD = rl x L | 0.7833525 | Ω |
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| 4 | **SIEMENS RELAY 7VK61** | | |
| | The CT Vk > Ipickup x [ Rct + Rrelay + 2 x Rlead ] / 1.3 | | |
| | Where $I_{HIGHSET}$ = Maximum Secondary Fault Current | 10 | Amp |
| | Vk > Ipickup x [ Rct + Rrelay + 2 x Rlead ] / 1.3 | 59.282 | Volts |
| | **Vk (800V) > 59.3V** | OK | |
| 5 | **AREVA RELAY P141** | | |
| | As per Manual Recommendations, 5P10, 10VA CT is OK. | | |
| | The offered CT is class PX, with high knee point voltage, must be adequate with P141 | | |
| 6 | **CRITERION FOR OC/EF RELAY 7SJ64** | | |
| | The OC/EF + 50BF relay 7SJ64 is connected to class X CT. Its equivalent P class CT parameters are calculated by the formula, Sn = [ 1.3 x Vk - Fn x In x Rct ] x In / Fn, Where | | |
| | Fn = CT Accuracy Limiting Factor at Rated Burden | 20 | |
| | Sn = CT Rated VA Burden = = [ 1.3 x Vk - Fn x In x Rct ] x In / Fn | 46 | |
| | The Criterion for any P class CT used for OC/EF protection, in general is given by , Fa = Fn x [ Sin + Sn ] / [ Sin + Sa ] | | |
| | Fn = CT Accuracy Limiting Factor at Rated Burden | 20 | |
| | | | |
| | Sin = CT Internal Burden = In2 x Rct | 6 | VA |
| | Sa = CT Connected Burden = $In^2$ x [ Rlead x 2 + Rrelay ] | 1.706705 | VA |
| | CT Accuracy Limiting Factor at Rated Burden, Fn | 20 | |
| | Actual Accuracy Limiting Factor, Fa = Fn x [ Sin + Sn ] / [ Sin + Sa ] | 134.95 | |
| | Maximum Secondary Short Circuit Current, Issc = Maximum Primary ( 40kAmp ) / CT Primary | 10 | |
| | The Actual Accuracy Limiting Factor has to be compared with the maximum secondary short circuit current, and Fa is OK if Fa > $I_{HIGHSET}$ | Fa IS OK | |
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| 1 | **CT DETAILS** | | |
| | CT No | T1 CORE-1 | |
| | Function | METERING | |
| | Meter Type | Alpha-A3 | |
| | CT Primary ( Amp) | 4000-2000 | Amp |
| | Adopted Tap ( Amp) | 2000 | Amp |
| | CT Secondary | 1 | Amp |
| | CT Class | 0.2FS5, 30-15VA | |
| | CT Resistance, Rct ( Assumed ) | 3.5 | Ω (Assumed ) |
| 2 | **METER BURDEN DETAILS** | | |
| | Connected Burden is the Energy Meter Alpha-A3RAQ | | |
| | Alpha Meter CT Resistance per phase | 0.1 | milli Ohm |
| | Meter Burden at CT Secondary Rated Current = $In^2$ x Rmeter | 0.0001 | VA |
| 3 | **CT LEAD BURDEN** | | |
| | Lead Length ( One Way ), L | 200 | metre |
| | Lead Size, A | 4 | $mm^2$ |
| | Lead Resistance per metre, rl | 0.00522235 | Ω / metre |
| | Total Lead Resistance, RLEAD = rl x L | 1.04447 | Ω |
| | | | |

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| 4 | **CRITERION FOR METERING CLASS CT ADEQUACY** | | |
| | The Criterion for any P class CT used for OC/EF protection, in general is given by , Fa = Fn x [ Sin + Sn ] / [ Sin + Sa ] | | |
| | Fn = CT Accuracy Limiting Factor at Rated Burden | 5 | |
| | Sn = CT Rated VA Burden | 15 | VA |
| | Sin = CT Internal Burden = $In^2$ x Rct | 3.5 | VA |
| | Sa = CT Connected Burden = $In^2$ x [ Rlead x 2 + Rrelay ] | 2.08904 | VA |
| | CT Accuracy Limiting Factor at Rated Burden, Fn | 5 | |
| | Actual Accuracy Limiting Factor, Fa = Fn x [ Sin + Sn ] / [ Sin + Sa ] | 16.55 | |
| | Maximum Secondary Short Circuit Current, Issc = Maximum Primary ( 40kAmp ) / CT Primary | 20 | |
| | The Actual Accuracy Limiting Factor has to be compared with the maximum secondary short circuit current, and Fa is OK if Fa < Issc | Fa IS OK | |
| | Maximum Continuous Current for the meter | 20 | Amp |
| | Maximum Short Duration Current = 200% of Max Continuous Current | 40 | Amp |
| | The meter will be safe, since Fa < Maximum Short Duration Current | | |
| | | | |